

PATENT SPECIFICATION

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(54) RESILIENT ROLLERS

(71) We, XEROX CORPORATION of Xerox Square, Rochester, New York, United States of America, a corporation organized under the laws of the State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The formation and development of images on an imaging surface which may be the surface of a photo-conductor, by electrostatic means is well known. The basic xerographic process, as disclosed by C. F. Carlson in U.S. Patent 2,297,691 involves placing a uniform electrostatic charge on a photoconductive insulating layer exposing the layer to a light-and-shadow image to dissipate the charge on the areas of the layer exposed to the light, and developing the resulting electrostatic latent image by depositing on the image a finely-divided marking material referred to in the art as "toner". The toner will normally be attracted to those areas of the layer which retain a charge, thereby forming a toner image corresponding to the electrostatic latent image. This powder image may then be transferred to a support surface such as paper. The transferred image may subsequently be permanently affixed to a support surface as by heat. Instead of latent image formation by uniformly charging a photoconductive layer and then exposing the layer to a light-and-shadow image, one may form the latent image by directly charging an imaging surface in image configuration. The powder image may be fixed to the imaging surface if elimination of the powder image transfer step is desired. Other suitable means such as solvent or overcoating treatment may be substituted for the foregoing heat fixing steps.

Several methods are known for applying a developer to an electrostatic latent image to be developed. One development method as disclosed by E. N. Wise in U.S. Patent 2,618,552 is known as "cascade" develop-

ment. Another method of developing electrostatic images is the "magnetic brush" process as disclosed for example, in U.S. Patent 2,874,063. Still another development technique is the "powder cloud" process as disclosed by C. F. Carlson U.S. Patent 2,221,776.

An additional dry development system involves developing an electrostatic latent image with a powdered developer material, the powder having been uniformly applied to the surface of a powder applicator. The latent image is brought close enough to the developer powder applicator so that the developer powder is pulled from the powder applicator to the charge bearing image in image configuration. The latent image and powder applicator may desirably be brought in contact including contact under pressure to affect development. The powder applicator may be either smooth surfaced or roughened so that the developer powder is carried in the depressed portions of the patterned surface. Exemplary of this system are the techniques disclosed by H. G. Greig in U.S. Patent 2,811,465.

Liquid development may also be employed in the development of electrostatic latent images. In conventional liquid development, more commonly referred to as electrophoretic development, an insulating liquid vehicle having finely divided solid material dispersed therein contacts the imaging surface in both charged and uncharged areas. Under the influence of the electric field associated with the charged image pattern the suspended particles migrate toward the charged portions of the imaging surface separating out of the insulating liquid. This electrophoretic migration of charged particles results in the deposition of the charged particles on the imaging surface in image configuration.

An additional liquid technique for developing electrostatic latent images is the liquid development process disclosed by R. W. Gundlach in U.S. Patent 3,084,043. In this method, and electrostatic latent image is

developed or made visible by presenting to the imaging surface a liquid developer on the surface of a developer dispensing member having a plurality of raised portions defining a substantially regular patterned surface and a plurality of portions depressed below the raised portions. The depressed portions contain a liquid developer which is maintained out of contact with the electrostatographic imaging surface. When the raised areas of the developer applicator are brought into contact with the imaging surface bearing an electrostatic latent image, the developer creeps up the sides of raised portions in contact only with the charged area of the imaging surface, and is deposited thereon.

This technique is to be distinguished from conventional liquid development wherein there is an electrophoretic movement of charged particles suspended in a liquid carrier vehicle to the charged portion of the image bearing surface while the liquid substantially remains on the applicator surface and serves only as a carrier medium. In the liquid development method described by R. W. Gundlach in U.S. Patent No. 3,084,043 the liquid phase actively takes part in the development of the image since the entire liquid developer is attracted to the charged portions of the image bearing surface. Furthermore, in the liquid development method described by R. W. Gundlach, unlike conventional liquid development, the developer liquid contacts only the charged portions of the image bearing surface.

A further liquid development technique is that referred to as "wetting development" or selective wetting described in U.S. Patent 3,285,741. In this technique an aqueous developer uniformly contacts the entire imaging surface and due to the selected wetting and electrical properties of the developer substantially only the charged areas of the normally hydrophobic imaging surface are wetted by the developer. The developer should be relatively conductive having a resistivity generally from about 10^5 to 10^{10} ohm cm and have wetting properties such that the wetting angle measured when the developer is placed on the imaging surface is smaller than 90° at the charged areas and greater than 90° in the uncharged areas.

In a compact electrostatographic copying device employing the development techniques disclosed by R. W. Gundlach, the imaging surface and the liquid developer applicator are desirably small diameter cylinders or the like, to facilitate the cooperative movement of the surfaces in contact during development in a confined space. Such moving contact between the imaging surface and the applicator resulting in the transfer of liquid developer from the applicator to the photoreceptor occurs at development speeds

ranging generally from about two to about 70 inches per second.

Prior imaging surfaces and the applicators have generally been rigid and have been manufactured by machining large castings to the proper diameter within precise tolerances. A functional surface such as a photoconductive film or a patterned applicator surface may subsequently be applied to the casting to achieve the necessary high degree of precision desirable for the proper functioning of the surface in an electrostatographic apparatus. Although, these prior imaging and applicator surfaces reproduce a large volume of high quality images before replacement is required, an appreciable amount of savings may be realized by employing a special expandable support cylinder as an integral part of the machine to allow the replacement of a substantially less expensive relatively thin outer sleeve.

It has been proposed in our copending application No. 1,427,947 that one of the co-operating surfaces (either the photoreceptor or the applicator) be deformable, having a hardness of from about 30° to about 90° (Shore A Durometer) while retaining the functional integrity of its operative surface. The use of a deformable surface when at least one of such surfaces is arcuate, provides substantially uniform contact and a substantially uniform nip width between the surfaces.

Such an arrangement in effect compensates for a range of dimensional irregularities in the non-deformable surface so that substantially uniform density good image quality and high resolution are achieved in the final copy. Resilient imaging and applicator surfaces are desirable to obtain good density and resolution, particularly in connection with out-of-contact liquid development.

It is an object of this invention to at least substantially overcome the disadvantages of the prior art.

According to the invention there is provided a resilient roller comprising a flexible cylindrical layer of metal supported on a tubular resilient member and a means central to the tubular resilient member for urging it radially against the flexible cylindrical surface.

Such a cylindrical resilient roller is suitable for use in the development of electrostatic latent images. It is suitable for use both as a photoconductor and as a developer applicator particularly in the liquid development method described by R. W. Gundlach. The flexible metal layer is easily fitted over the tubular resilient member and is easily removed therefrom when on site servicing of the imaging surface is desirable.

When the cylindrical resilient roller is used as a photoconductor, any suitable flexible

photoconductor sleeve may be used. Typical of such photoconductor sleeves are flexible conductive substrates overcoated with a photoconductive insulating layer. A preferred flexible imaging surface is a brass sleeve overcoated with selenium. Brass is both strong and flexible at relatively thin thicknesses and is easily coated with a uniform layer of selenium, a photoconductive insulator. Any suitable coating method may be used. Typically the photoconductive insulating layer is vacuum coated on to the conductive substrate. Although, brass is a preferred substrate for the flexible imaging sleeve, other malleable conductive metals such as copper, aluminum and nickel are also useful and any suitable conductive material may be used.

When the cylindrical resilient member is used as a developer applicator, such as an applicator for the liquid development method described by R. W. Gundlach, any suitable flexible applicator sleeve may be used. Typical such flexible applicator sleeves are metal foils embossed with a pattern of lands and valleys and metal sleeves having a spiral groove pattern embossed on its circumference.

Whether it is a developer applicator or a photoconductive layer, the flexible cylindrical layer should be able to bend repeatedly without breaking.

The flexible cylindrical layer is supported on a tubular resilient member. The tubular resilient member, when in its normally relaxed state, fits within the flexible cylindrical layer with sufficient clearance that the sleeve may be easily removed from the tubular resilient member.

The tubular resilient member may be of any suitable resilient material. Typical such materials are rubbers capable of regaining their original size and shape after deformation. A preferred resilient material is nitrile rubber because it is not adversely effected by oil-based liquid developers which are frequently used in electrostaticographic copying devices.

The tubular resilient member may be of any suitable thickness sufficient to provide the flexible imaging sleeve with structural integrity and some resilient properties when radially urged thereagainst. Varying thicknesses of the tubular resilient member may be desirable depending on the width of the nip which is sought to be achieved between the photoconductive member and the developer applicator. As is disclosed in greater detail in our copending application No. 1,427,947, a wider nip width may be desirable whenever faster machine speeds or lower viscosity liquid developers are used in an electrostaticographic copying device.

Any suitable means may be used for urging the resilient tubular member against the

flexible cylindrical surface. Typical such means are mechanical linkages and resilient means for producing an outward radial pressure on the inside surface of the resilient tubular member which in turn urges the resilient tubular member against the flexible sleeve. Typical examples are described in the following drawings. These arrangements are capable of imparting any desired hardnesses to the flexible cylindrical surface through the resilient tubular member. Typically the range of hardness for providing nip widths for development is from about 30° to about 90° (Shore A durometer).

Although other such arrangements are possible, satisfactory results are obtained with the arrangements shown in the drawings.

Resilient rollers according to the invention will now be described with reference to the accompanying drawings in which:

Fig. 1 shows in cross-section one roller;

Fig. 2 is a cross-sectional view taken along the line 2-2 of Fig. 1;

Fig. 3 is a cross-sectional view taken along the line 2-2 in the opposite direction to Fig. 2;

Fig. 4 is a cross-sectional view of another roller;

Fig. 5 is a cross-sectional taken along lines 5-5 of Fig. 4; and

Fig. 6 shows schematically an electrostaticographic device employing the present invention.

Referring more specifically now to Fig. 1 there is shown in longitudinal cross-section along its axis a portion of a resilient roller 1 wherein the flexible cylindrical layer 2 is a brass substrate coated with selenium. The brass may be rolled or drawn into the proper shape and vacuum coated with selenium. Flexible cylindrical layer 2 is supported on resilient tubular member 3 which may be for example, nitrile rubber. The resilient tubular member 3 is urged against the flexible cylindrical layer 2 by a means 4 which in this embodiment comprises a rigid arcuate member 5 which is axially divided into at least three sections and is radially urged against the resilient tubular member 3 by a washer shaped second resilient member 6. Second resilient member 6 is expanded radially when nut 7 is turned on threaded shaft 8 to press the flat, solid washer 9 against the second resilient member 6. In the embodiment shown in Fig. 1, a second means (not shown) similar to means 4 is located at the opposite end of the resilient roller 1. The resilient roller 1 may be installed in an electrostaticographic copying device (not shown) by bearing connections with threaded shaft 8.

Referring more specifically now to Fig. 2, there is shown in cross-section the resilient roller 1 of Fig. 1 along lines 2-2 of Fig. 1

1. The flexible cylindrical layer 2 is supported on resilient tubular member 3 which is urged against the inside surface of the flexible layer 2 by rigid arcuate member 5 which has been axially separated into three sections 5a, 5b and 5c.

Referring more specifically now to Fig. 3, there is shown in cross-section the resilient roller 1 as described in Figs. 1 and 2 along lines 2-2 of Fig. 1 in a relaxed position. The rigid arcuate member 5 is not in a position to exert a pressure on the resilient tubular means 3, and the resilient tubular means 3 is not urged against the inside surface of the flexible cylindrical layer 2. In such an arrangement the flexible layer 2 may be easily removed from the resilient tubular member 3.

Referring more specifically now to Fig. 4, there is shown schematically in partial longitudinal cross-section an alternative embodiment of the present invention wherein the flexible cylindrical layer 17 is an aluminum layer having a pattern of grooves and ridges embossed in its outer surface so that it may be used as a liquid developer applicator means. The pattern of grooves and ridges function as lands and valleys in the liquid development system described by R. W. Gundlach. The pattern may be roll-embossed on the flexible cylindrical surface or cut, for example, in a helical groove pattern around the surface. In Fig. 4 the means 18 for urging the resilient tubular member 19 against the flexible cylindrical applicator layer 17 comprises a threaded shaft 20 and a series of petals 9 which are circularly spaced around the threaded shaft 20 and pivotally connected between the threaded shaft 20 and the rigid arcuate member 21 and a threaded nut 22 for moving the threaded shaft 20 relative to the rigid arcuate member 21. Rigid shaft 20 also serves to connect the resilient imaging member to a copying device. As in Fig. 1 the rigid arcuate member 21 of Fig. 4 has been separated axially into sections. In a relaxed position the flexible cylindrical layer 17 can be easily removed from the resilient tubular member 19. In order to cause the resilient tubular member 19 to be urged against the inside diameter of the flexible cylindrical imaging layer 17 the bolt 22 is turned on threaded shaft 20 to cause the petals 9 to be urged against the sections of the rigid arcuate member 21.

Referring more specifically now to Fig. 5, there is shown in cross-section the resilient roller of Fig. 4 along lines 5-5. The petals 9 are shown pivotally connected to threaded shaft 20 and to rigid arcuate member 21 so as to exert a uniform outward radial pressure on the tubular resilient member 19 which provides resilient properties to the flexible cylindrical layer 17.

Referring more specifically now to Fig. 6 there is shown schematically and in cross-section an electrostatographic copying device 10 employing the present invention. The device comprises resilient roller 23 which has a photoconductive surface and which rotates as shown past charging corona 11 which places a uniform charge on the imaging member then rotates past imaging station 12 where it is exposed to a light and shadow image of the original 13 sought to be copied. Such exposure removes the charge in the light struck areas of the resilient roller 23. After imaging, the resilient roller 23 is moved in sequence past the development station 14 and the transfer station 15 where, respectively, the image is developed onto the resilient roller 23 and transferred to an image receiving means 16, such as plain paper. The resilient roller 23 then rotates past cleaning station 24 where, for example, it may be cleaned by a wiper blade 25.

WHAT WE CLAIM IS:—

1. A resilient roller comprising a flexible cylindrical layer of metal supported on a tubular resilient member and a means central to the tubular resilient member for urging it radially against the flexible cylindrical layer.

2. The resilient roller of Claim 1 wherein the flexible cylindrical layer has a photoconductive insulating layer coated thereon.

3. The resilient roller of Claim 2 wherein the photoconductive insulating layer is selenium.

4. The resilient roller of Claim 2 or 3 wherein the metal layer is of brass.

5. The resilient roller of Claim 1 wherein the flexible cylindrical layer is a developer applicator.

6. The resilient roller of Claim 5 wherein the flexible cylindrical layer has a pattern of recesses on its outer surface.

7. The resilient roller of any of the preceding claims wherein the resilient tubular member is nitrile rubber.

8. The resilient roller of any of the preceding claims wherein the means for urging the tubular resilient member radially against the flexible cylindrical layer comprises a rigid arcuate member which is axially divided into at least three segments arranged to be radially urged against the inner surfaces of the tubular resilient member.

9. A method for developing a charge pattern on a resilient imaging surface comprising forming the charge pattern on the resilient imaging surface and bringing the surface into developing relationship with a developer applicator, said resilient imaging surface comprising a flexible cylindrical layer of metal supported on a resilient tubular member which is urged radially against

the inner surface of the flexible cylindrical layer by a means central to the tubular resilient member.

5 10. The method of Claim 9 wherein the flexible cylindrical layer has a photoconductive insulating material coated thereon.

11. The method of Claim 10 wherein the photoconductive insulating material is selenium.

10 12. The method of Claim 10 or 11 wherein the metal layer is of brass.

13. The method of any one of Claims 9 to 12 wherein the resilient member is of nitrile rubber.

15 14. The method of any one of Claims 9 to 13 wherein the means for urging the tubular resilient member radially against the flexible cylindrical layer comprises a rigid arcuate member which is axially divided into at least three segments which may be radially urged against the inner surface of the tubular resilient member.

20 15. A method for developing a charge pattern comprising forming the charge pattern on a charge bearing surface and bringing the charge bearing surface into developing relationship with a resilient roller which comprises a flexible cylindrical layer of

metal supported on a resilient tubular member which is urged radially against the inner surface of the flexible cylindrical layer by a means central to the tubular resilient member.

30 16. The method of Claim 15 wherein the flexible cylindrical layer has on its outer surface a pattern of recesses for holding a developer material and for presenting a developer material to the charge bearing surface.

40 17. The method of Claim 15 or 16 wherein the tubular resilient member comprises nitrile rubber.

45 18. The method of any one of Claims 15 to 17 wherein the means for urging the tubular resilient member radially against the flexible cylindrical layer comprises a rigid arcuate member which is radially divided into at least three segments which may be radially urged against the inner surface of the tubular resilient member.

50 19. A resilient roller substantially as described with reference to the accompanying drawings.

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